The Role of Hillslope Failures and Internal Climate Variability in Climate Change Impact Assessment on Debris Flows and Sediment Yield in an Alpine Catchment

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Sediment production and transfer processes shape river basins and networks and are driven by variability in precipitation, runoff and temperature. Changes in these hydrological and geomorphological processes are especially difficult to predict in temperature-sensitive environments such as the Alps. In this study, we use a chain of climate-hydrology-geomorphology models to quantify possible impacts in a debris flow-prone catchment in the Swiss Alps (Illgraben). To this end, we combine a stochastic weather generator[1] with downscaled and bias-corrected climate change projections[2]. These climate simulations are fed to a hillslope-channel sediment cascade model[3], which is calibrated against observed debris-flow magnitudes estimated from force plate measurements[4].

The results highlight the role of hillslope landslides, supplying sediments to the channel, where they can be re-mobilized if sufficient surface runoff is generated. In supply-unlimited conditions, a rather uncertain rise in precipitation combined with a certain rise in air temperature leads to an increase in sediment yield of ~50% by the end of the 21st century. In contrast, if sediment production is considered with a simplified frost-weathering mechanism, future sediment supply is reduced and hence also sediment yield (~ -50%) and the annual number of debris flows (~-25%). We further demonstrate the elevation dependency of the frost-weathering mechanism: at higher elevations a shorter season with snow cover could increase the time bedrock is exposed to freezing temperatures and accelerate sediment production. Although results underlie major uncertainties, we show that these uncertainties can be attributed mainly to irreducible internal climate variability. Therefore, our findings have important implications for the assessment of natural hazards and risks in mountain environments.

REFERENCES

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